TEACHER NOTES – ASTRONOMY IN THE NEWS #24
THE DART MISSION LAUNCHES

Slide 2 – Background Science: Planetary Defence

The fate of the dinosaurs was a mass extinction event caused by a collision by an asteroid thought to be 10-15 kilometres across. It is, therefore, in the best interests of the human race to have a knowledge of where any potential hazardous asteroids or comets are. This cause is coined “Planetary Defence” and accounts for multiple stages of the process. These are to Assess objects; Search, Detect and Track; Characterise; Plan & Coordinate; and Mitigate.

The Search, Detect and Track aspect of the cause has resulted in the detection of thousands of Near Earth Objects (NEOs). NEOs are those objects that come within 1.3 AU (astronomical units) of the Sun. However, not all of these objects would be hazardous as they are either too small (an asteroid of 35m across is thought to pose a threat to a city) or don’t come within 8 million kilometres of the orbit of Earth. However, the objects that are larger than this and do come within this threshold are labelled as Potentially Hazardous Objects.

IMAGES:

1. (Left) The orbits of NEOs drawn in relation to the orbits of Mercury, Venus, Earth, Mars and Jupiter. The objects shown all have a size over 140 m and come within 7.6 million kilometres of Earth.
2. (Top Right) GIF of the NEOs around the Earth. This animation displays that these orbits don’t directly cross the Earth (i.e. don’t collide with Earth).
3. (Bottom Right) Histogram of sizes of all known NEOs. The vast majority of these objects are not those that would cause catastrophic damage to the entirety of humanity. However, the majority of the detected objects with sizes do meet the threshold for Potentially Hazardous Objects.

Slide 3: The DART Mission

The previous slide described the stages of the Planetary Defence strategy. The Mitigate stage is to try and stop or limit the damage that could be done by an asteroid on a collision course with Earth. As part of this plan, NASA has launched the DART mission, Double Asteroid Redirection Test.

DART is a mission to attempt to deflect an asteroid by colliding with it. DART is targeting a 160 metre asteroid moon, or moonlet called Dimorphos, that is orbiting a much larger asteroid, Didymos. The larger Didymos is about 780 m across, but Dimorphos is much closer in size to the asteroids that would be expected to cause issues for Earth in the future.

By deliberately colliding with the Dimorphos moonlet, the DART spacecraft will alter the velocity of Dimorphos and will thus change the orbit. This change will not be significant, but will be enough to be observable from Earth. The collision is expected to change the orbit period of Dimorphos by 10 minutes, with it currently 11.92 hours. Whilst Didymos will not collide with Earth at any point, this experiment will determine if it is indeed possible to knock a asteroid off an orbit and away from a possible catastrophic collision with Earth!

The articles that this bulletin is built on can be found here:

https://www.bbc.co.uk/news/science-environment-59327293

https://www.theguardian.com/science/2021/nov/22/nasa-slam-spacecraft-into-asteroid-to-avoid-armaggedon

A couple of websites that give some more information are here:

https://www.nasa.gov/planetarydefense/dart

https://dart.jhuapl.edu/

IMAGES:

1. (Top left) Cartoon of the DART spacecraft with its solar panels fully extended.
2. (Bottom left) Cartoon of the change in orbit of Dimorphos around Didymos caused by the collision with the DART spacecraft. This slight change will cause the orbital time to change by 10 minutes, or just over one percent.
3. (Top right) Radar images from the Arecibo telescope. These 14 images were taken over three days in November 2003, and show the two bodies within the Didymos system. The larger Didymos is the body at the bottom of the images, whilst Dimorphos is the small body visible to the top of each image.
4. (Bottom right) Simulated images of the Didymos system produced by combining the radar images and light curve information. The larger body is 780 m in size, whilst Dimorphos is 160 m across with a separation of just over 1 km.

Slide 4 – Activity: How much is the orbit changed?

This week's activity is a mathematical one in which the students will calculate how much the orbital radius is changed after the collision with DART. Using Kepler's 3rd law of:

$$T^2 = \frac{4\pi}{GM}a^3$$

Where T is the orbital period, G is the gravitational constant, M is the central mass and a is the orbital radius.

The students are given the initial orbit of 11.92 hours and the new orbital period of 11.75 hours and an assumed original orbit of 1km. By setting the constants (M won't change) equal to each other and rearranging, you should be left with the following relationship:

$$\frac{T_{new}^2}{T_{original}^2} = \frac{a_{new}^3}{a_{original}^3}$$

By substituting in the values, a new orbital radius of 0.99 km should be found.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	8.4, 8.6, 8.7, 11.1, 11.26, 11.27

A-Level Physics Specifications:

Specification	Knowledge Point
OCR Physics A	5.4.3(c,d)
AQA Physics	3.7.2.4